BODY COMPOSITION IN MILITARY SERVICES: STANDARDS & METHODS

J. A. Hodgdon

REPORT No. 90-21

NAVAL HEALTH RESEARCH CENTER
P.O. BOX 85122
SAN DIEGO, CALIFORNIA 92186-5122

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
BETHESDA, MARYLAND

BODY COMPOSITION IN THE MILITARY SERVICES: STANDARDS & METHODS

James A. Hodgdon, Ph.D.

Naval Health Research Center
San Diego, CA 92186-5122

Report No. 90-21 supported by the Naval Medical Research and Development Command, Bureau of Medicine and Surgery, Department of the Navy, under Research Work Unit M0096-PN.002-6003. This paper was presented at the meeting of the National Academy of Sciences, Committee on Military Nutrition, 06 February 1990 in Washington, DC. The views presented are those of the author, and do not reflect the official policy of the Department of the Navy, Department of Defense, nor the U.S. Government.

SUMMARY

1. This paper deals with two topics: The development of body composition standards in the U.S. Navy; and the methods of body composition assessment in use by the military Services today.

2. In 1981, the Services were directed to develop body composition and fat standards consistent with the mission of the Services. Three concerns were outlined which dictated the establishment of weight control policy: 1) body composition was an integral part of physical fitness; 2) body composition is a determinant of appropriate military appearance; and 3) body composition is a determinant of general health and well-being of military personnel. Each of these three concerns was explored as a basis for setting standards for body composition in the Navy.

3. Our investigations of relationships between body composition variables and performance of materials handling tasks suggest that percent fat is not strongly related to such performance. Estimated fat-free mass, on the other hand, is highly correlated with strength and the ability to lift objects.

4. Investigations of relationships between rated military appearance and percent body fat by Vogel and colleagues reveals military appearance can be determined reliably, and that percent body fat is only moderately well correlated with military appearance ($r = 0.53$ for men; 0.46 for women). Fatness was not found, by itself, to be a reasonable indicator of military appearance.

5. In 1985, the National Institutes of Health determined, based on the findings of a consensus conference on body composition and health, that obesity (defined as a fat level posing significant health risk to the individual) could be defined as a body weight for height which exceeded the midpoint for the medium frame individual on the 1983 Metropolitan Life Insurance tables by 20%. A study was undertaken to determine the percent fat equivalent of this weight-based definition.

6. Equations were developed from the Naval Health Research Center body composition data base to predict percent fat from height and weight. These equations were applied to the 120% weight values for each height. Percent fat values were found to be rather constant across heights, especially for females. Mean values for critical percent fat across height were 22.0 $\pm$1.20 for males, and 33.5 $\pm$0.18 for females.

7. Standards for Navy personnel were based on these critical percent fat values. Since the Navy equations to predict fat have standard errors of about 3.5 % fat, it was decided that the standard for administrative action should be at least one standard error above the critical percent fat values. Thus the Navy standards of 26% fat for males and 36% fat for females, were arrived at.

8. It was concluded that while there is a need to validate the relationship between body composition and health outcomes expressed in this paper, the most rational basis for setting body composition standards for the military appears to be health considerations.

9. In the measurement of body composition, all four Services have adopted the use of body circumferences, in conjunction with height and weight, to predict percent body fat. Circumference measurements are made more reliably and learned more easily than skinfold thickness measurements. Circumference measurement sites selected for prediction equations varies by gender and Service. Multiple correlations for the development of the equations range from 0.73 for the Marine Corps female equation to 0.90 for the Navy male equation.

10. Cross-validation of the military equations on a sample of U.S. Navy personnel shows the percent fat predicted from the equations to have a mean correlation of 0.85 (range = 0.89 to 0.74) for males and a mean correlation of 0.80 (range = 0.84 to 0.78) for females with percent fat from hydrostatic weighing. Standard errors of measurement average 4.15% fat for males and 4.23% fat for females.

11. It was concluded that the equations in use by the military Services have similar validities and standard errors of measurement to other, published generalized anthropometric equations, and would appear to be reasonable, useful estimators of body composition.

BACKGROUND

This paper will discuss two topics: The development of standards for body composition in the U.S. Navy, and the methods of body composition assessment in use by the military Services today.

In 1981, the Department of Defense (DoD) issued Directive 1308.1. Part of the policy expressed in that directive was that the "determining factor in deciding whether or not a service member is overweight is the member's percent body fat." The services were directed to determine body composition and fat standards consistent with the mission of the Services.

The directive also indicated that there were three concerns relating to the need for establishment of a weight control policy: Firstly, body composition is considered an integral part of physical fitness and is, therefore, essential in maintenance of combat readiness. This statement implies a relationship between fatness and military performance. Secondly, control of body fat is considered necessary to maintain appropriate military appearance. Thirdly, control of body fat is considered important in maintaining the general health and well-being of armed forces personnel.

The directive left the task of developing the most appropriate methodology for body fat determination to the individual services. The directive did require that fat measurement techniques must have a correlation coefficient of 0.75 or better with percent fat from underwater weighing. This coefficient has since been increased to 0.85. DoD percent fat goals were set at 20% fat for males and 26% fat for females.

BODY COMPOSITION STANDARDS

If body composition was presumed to affect military performance, military appearance, and general health and well-being, the basis for setting standards ought to lie with one of these three relationships. Below is the line of argument followed within the U.S. Navy to arrive at suitable standards for body composition.

Body Composition and Physical Performance.

Performance on the Navy's biannual Physical Readiness Test (PRT), is taken to be an indicator of a sailor's readiness for combat. As an adjunct to setting standards for physical fitness and body composition, studies were carried out which investigated relationships between performance on the PRT items and performance of materials handling tasks. The Navy's PRT includes a body composition assessment, sit-reach distance, time for a 1.5-mile run, number of situps which can be performed in 2 minutes, and number of pushups which can be performed in 2 minutes. Work by Robertson and Trent (1985) at the Navy Personnel Research and Development Center, showed that the majority of the physically demanding jobs performed by Navy personnel were materials handling tasks: Lifting, carrying, and pulling, with the most common being carrying while walking (48%) and lifting without carrying (20%). Performance on such tasks might form a reasonable basis for setting standards for shipboard work.

Beckett and Hodgdon (1987) investigated associations between PRT items, body composition variables, and performance on two materials handling tasks. The two tasks were: the maximum weight of a box which could be lifted to elbow height, the total distance a 34-kg box could be carried on alternate laps of a 51.4 m. course during two 5-minute work bouts. The parameters of the carry task represented median values of the weight, distance, and timing of Robertson and Trent's survey of carry tasks performed aboard ship. Table 1 shows the correlations between PRT and body composition items, and performance on the lift and carry.

Table 1.
Correlations, Navy Physical Readiness Test Items, and Body Composition with Materials Handling Tasks.
(N = 64 male, & 38 female Navy personnel)

	Box Lift Max Wt.	Box Carry Power
Sit-Reach distance	-0.21	0.01
Situps in 2 minutes	-0.00	0.31
Pushups in 2 minutes	0.63	0.56
1.5-mile run time	-0.34	-0.67
Percent fat (from circs.)	-0.36	-0.43
Fat-free mass	0.84	0.44
Fat mass	0.08	-0.23

Inspection of Table 1 reveals percent body fat to be only modestly correlated with these materials handling tasks. These modest correlations suggest that using relationships between these tasks and percent fat as the basis of setting percent fat standards would not be particularly fruitful. However, it might be noted that one of the body composition variables (fat-free mass) is highly correlated with the box lift maximum weight. In this study fat-free mass was found to be highly correlated with other muscle strength measures. The possibility exists for using fat-free mass as an approximation of overall strength in job assignment.

Body Composition and Appearance.

The second stated reason for wanting to maintain appropriate levels of body fat is for the maintenance of proper military appearance. It is the Navy's policy that appearance judgments are subjective and not necessarily strongly related to fatness. Current performance evaluation procedures allow for the entry of these subjective assessments, and they need not be anchored to other objective variables.

The soundness of this approach was recently tested by Hodgdon, Fitzgerald, and Vogel (1990). A panel of 11 U.S. Army headquarters staff rated the "military appearance" of 1075 male and 251 female U.S. Army personnel dressed in Class A

uniform. A 5-point scale was used for the ratings. The personnel who were rated also had their percent body fat determined from underwater weighing. The inter-rater reliability of the ratings was quite good, (alpha = 0.86). The correlation between appearance ratings and percent fat was modest: 0.53 for ratings of male personnel, and 0.46 for ratings of female personnel. With only one quarter of the variance in ratings accounted for by fatness, it does not appear from this study that percent body fat, by itself, constitutes a reasonable indicator of military appearance. Clearly, other factors play a role in such judgments.

Body Composition and Health.

The DoD directive points out that one of the reasons for wanting to set body fat standards is the maintenance of health and well-being of the service members. It is in the relationships between health and fatness that the Navy has anchored its body composition standards.

On February 11-13, 1985, the National Institutes of Health Office of Medical Applications of Research, the National Institute of Arthritis, Diabetes, and Digestive and Kidney Diseases, and the National Heart, Lung, and Blood Institute convened a consensus development conference on the health implications of obesity. The conferees determined that obesity is related to a significant impairment of health, particularly in terms of increased risk of diabetes, hypertension, coronary artery heart disease, and cancer. They also agreed that obesity could be defined as a weight for height 20% above the midpoint weight listed in the 1983 Metropolitan Life Insurance tables for the medium frame individual.

Armed with this definition, and the information that obesity could be considered a health risk, we set out to determine whether or not these weight for height tables had any reasonable expression in percent body fat. Using the Navy anthropometry data set, we determined the regression between weight and height, and percent body fat. Table 2 provides the description of the data set used for development of the regressions.

Table 2
Regression Sample Descriptions

	Males (n=1024)	Females (n=340)
Age (yrs)	31.9 ±6.93	26.6 ±5.29
Height (cm)	177.6 ±6.96	164.5 ±6.71
Weight (kg)	85.7 ±14.45	62.2 ±9.35
% Fat (underwater weighing)	21.6 ±8.07	26.8 ±7.07

The regressions that were developed were:

$$\% \text{ Fat} = 0.464 \times WT(kg) - 0.411 \times HT(cm) + 54.769$$
$$(R = 0.75, \text{ see} = 5.33 \% \text{ Fat}) \text{ for } \textbf{males},$$

and

$$\% \text{ Fat} = 0.638 \times WT(kg) - 0.409 \times HT(cm) + 54.367$$
$$(R = 0.77, \text{ see} = 4.54 \% \text{ Fat}) \text{ for } \textbf{females}.$$

Using these equations, we then determined the percent fat value associated with the NIH critical weights at each height for both males and females. The results are provided graphically in Figure 1. As can be seen from Figure 1, the "critical" percent fat values are rather constant across heights, especially the values for females. Mean values for critical percent fat across height were 22.0 $\pm$1.20 for males, and 33.5 $\pm$0.18 for females.

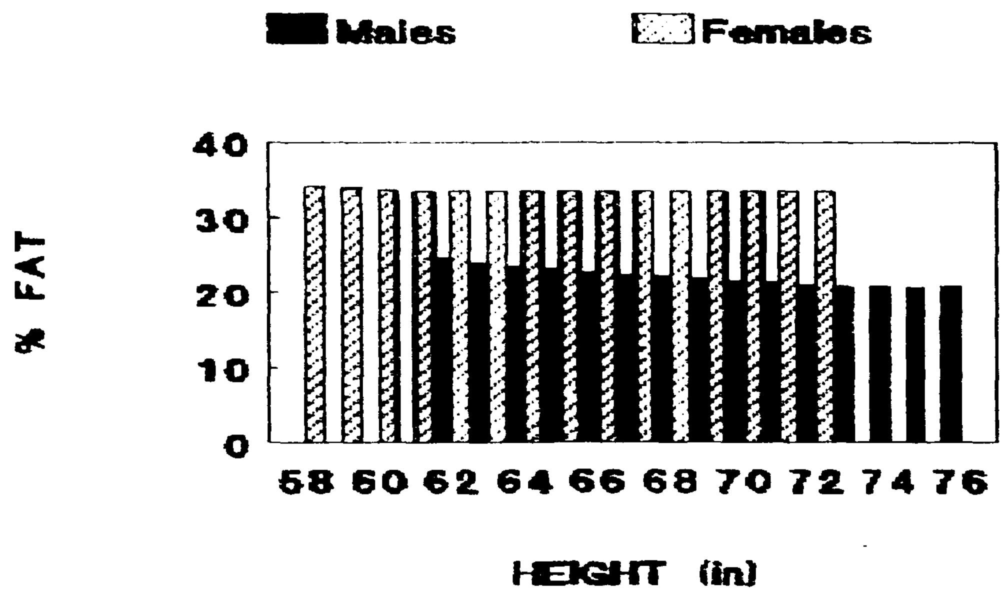

Figure 1.
NIH critical weights expressed as percent fat for each height.

Standards for percent body fat for Navy personnel were derived from these mean values. The circumference equations used by the U.S. Navy to predict body fat have standard errors of measurement of approximately 3.5% fat. It was decided that the standard for administrative action should be approximately one standard error above the critical percent fat, in order to minimize the number of false positives for individuals exceeding the NIH obesity definition. Thus values of 26% fat for men and 36% fat for women were adopted. Any sailor or officer exceeding these limits for three successive administrations of the Physical

Readiness Test is subject to administrative action. In addition, an "overfat" category was defined. Individuals exceeding values of 22% fat, if male, or 30% fat if female, are required to go on a fat reduction program. This approach allows remedial action on body fat reduction to begin prior to exceeding the limits for administrative action.

The finding that the NIH critical weights represent a relatively constant percent body fat for men and women is intriguing, especially when one considers that those weights derive from the empirically determined Metropolitan life insurance tables. However, there is a paucity of data relating body composition variables, themselves, to mortality and morbidity outcomes. Such epidemiological studies need to be done.

In summary, the Navy, finding a lack of basis for setting body composition standards based upon either performance or appearance, has chosen to base its standards upon health considerations. The standards are derived from the NIH consensus definition of obesity.

BODY COMPOSITION MEASUREMENT

The criteria for selection of methodologies for assessment of body composition in the military were that the measures must be able to be used easily in the field, the measures must be able to be made reliably, and must be valid indicators of fatness. It was also important that skill in measurement be relatively easily acquired. In order to meet these measurement technique requirements, all four services have adopted circumference measurements, often in conjunction with height and weight, as the basis for predicting percent body fat.

Reliability and Trainability.

In 1978, Mueller and Malina determined intra- and interexaminer reliabilities of skinfold and circumference measurements. They found both techniques to be quite reliable but, circumferences to be more reliably measured than skinfold thicknesses (0.97 and 0.96 for circumference intra- and interexaminer reliabilities, respectively; and 0.94 and 0.92 for skinfold reliabilities).

In addition to being slightly more reliably made, circumference measurements appear to be more easily learned. Heaney and coworkers (Beckett, Heaney, and Hodgdon, unpublished manuscript) investigated the time course of acquisition of skill in circumference and skinfold thickness measurement. Thirty eight active duty Navy personnel were provided six 1-hour training sessions during which they were trained and evaluated in skinfold measurements at two sites, and circumference measurements at three sites. Heaney and coworkers found that after 75 skinfold measurements at each site (150 total measurements), only 24% of the study participants had reached proficiency in skinfold measurement. On the other hand, 68% of the participants had reached proficiency after 45 circumference measurements at each site (135 total measurements). In this study, circumference measurement was clearly the more easily learned technique.

Equation Validity.

Each of the Services developed regression equations involving body circumference measurements, sometimes in conjunction with height and/or weight. The regression equations predict either body density, percent body fat, or fat-free mass. For the Army, Navy, and Marine Corps the criterion measurement for equation development was either body density from underwater weighing or percent fat using the Siri equation to convert body density to percent body fat. The Air Force equations use as a criterion measure, fat-free mass from tritiated water dilution, or body volume and weight (Allen, 1963).

United States Army.

The U.S. Army equations were developed by Vogel and coworkers (1988) at the U.S. Army Research Institute of Environmental Medicine on a large sample of U.S. Army personnel. The sample was not stratified to reflect distributions of demographic variables (e.g. age, gender, race, job classification) within the Army population. Table 3 contains the equations and descriptive data from the equation development sample. Sample descriptors are shown as mean ± standard deviation.

These equations are used in conjunction with weight for height tables which serve as an initial screening tool in the detection of overfat. Current Army body fat retention standards are based upon age. Standards for males are 20% fat for ages 16-20 years; 22% fat for ages 21-27 years; 24% fat for ages 28-39 years; and 26% for ages 40 years and greater. Standards for females are 28%, 30%, 32%, and 34% fat respectively for the same age groupings as the males.

Table 3.
UNITED STATES ARMY
BODY COMPOSITION EQUATIONS

MALES:

Equation:	Sample: U.S. Army Personnel		
$\% \text{ Fat} = 76.5 \times \text{Log}_{10}(\text{Abd.II} - \text{Neck})$	N	1126	
	Age (yrs):	30.2	± 8.9
$- 68.7 \times \text{Log}_{10}(\text{Height})$	Height (cm)	175.0	± 6.9
	Weight (kg)	77.1	±11.3
$+ 46.9$	% Fat	26.6	± 7.0

$R = 0.82$, $SEE = 4.02$

FEMALES:

Equation:	Sample: U.S. Army Personnel		
$\% \text{ Fat} = 105.3 \times \text{Log}_{10}(\text{wt})$	N	266	
$- 0.200 \times \text{Wrist}$	Age (yrs):	24.1	± 4.5
$- 0.533 \times \text{Neck}$	Height (cm):	162.6	± 6.2
$1.574 \times \text{Forearm}$	Weight (kg):	60.4	± 8.2
$+ 0.173 \times \text{Hip}$	% Fat	28.0	± 6.1
$- 0.515 \times \text{Height}$			
$- 35.6$			

$R = 0.82$, $SEE = 3.60$

Note: Circumference measurements and height are in cm.

United States Navy.

The U.S. Navy equations were developed by Hodgdon and Beckett (1984a, 1984b) at the Naval Health Research Center. Their large sample of U.S. Navy personnel was also non-stratified with respect to Navy demographics. Table 4 contains the Navy equations and a description of the equation development samples. Within the Navy every service member has his or her body fat estimated twice each year using these equations. There are no weight tor height screening tables used. As noted above the current retention standards are 26% fat for men, and 36% fat for women, irrespective of age.

Table 4.
UNITED STATES NAVY
BODY COMPOSITION EQUATIONS

MALES:

Equation:	Sample: U.S. Navy Personnel		
Dens. = $-.191 \times \text{Log}_{10}(\text{Ab.II} - \text{Neck})$	N	602	
	Age (yrs):	31.9	± 7.1
$+ 0.155 \times \text{Log}_{10}(\text{Height})$	Height (cm):	176.8	± 7.0
	Weight (kg):	84.3	±14.9
$+ 1.032$	% Fat	21.6	± 8.1

$$\% \text{ Fat} = 100 \times [(4.95 / \text{Dens.}) - 4.5]$$

R = 0.90, SEE = 3.52

FEMALES:

Equation:	Sample: U.S. Navy Personnel		
Dens. = $-.350 \times \text{Log}_{10}(\text{Ab.I+Hip+Neck})$	N	214	
	Age (yrs):	26.5	± 5.2
$+ 0.221 \times \text{Log}_{10}(\text{Height})$	Height (cm):	164.5	± 6.6
	Weight (kg):	61.7	± 9.3
$+ 1.296$	% Fat	27.0	± 6.9

$$\% \text{ Fat} = 100 \times [(4.95 / \text{Dens.}) - 4.5]$$

R = 0.85, SEE = 3.72

Note: Circumference measurements and height are in cm.

United States Marine Corps.

The Marine Corps was the first service to employ body composition estimation from circumferences. The Marine Corps equations were developed by Wright, Dotson, and Davis (1980, 1981) from the Institute of Human Performance from data collected by Wright and Wilmore (1974) on Marine Corps personnel. Table 5 contains the Marine Corps equations and description of the equation development sample.

The Marine Corps uses weight for height tables as the basis for weight control decisions. If a Marine is overweight by the tables, but does not appear to be fat, he/she may have a body fat estimation done. If the individual's body fat is less than the Marine Corps standards of 18% fat for men and 26% fat for women, a new maximum allowable weight is calculated and entered into the Marine's record.

Table 5.
U.S. MARINE CORPS
BODY COMPOSITION EQUATIONS

MALES:

Equation:	Sample: U.S. Marine Corps Personnel		
% Fat = 0.740 x Abdomen II	N	279	
	Age (yrs):	28.7	± 8.2
− 1.249 x Neck	Height (cm):	177.1	± 6.3
	Weight (kg):	77.9	± 9.8
+ 40.985	% Fat	16.5	± 6.2

R = 0.81, SEE = 3.67

FEMALES:

Equation:	Sample: U.S. Marine Corps Personnel		
% Fat = 1.051 x Biceps	N	181	
− 1.522 x Forearm	Age (yrs):	23.1	± 5.9
− 0.879 x Neck	Height (cm):	164.3	± 6.3
+ 0.326 x Abdomen II	Weight (kg):	59.3	± 6.7
+ 0.597 x Thigh	% Fat	23.1	± 5.9
+ 0.707			

R = 0.73, SEE = 4.11

Note: Circumference measurements are in cm.

United States Air Force.

The U.S. Air Force body composition equation for men was developed by Fuchs and coworkers (1978) at the U.S. Air Force School of Aerospace Medicine. The equation for women was developed by Brennan (1974) as part of her Master's work at the Incarnate Word College in San Antonio. Table 6 contains the Air Force equations and descriptions of the development samples. In Table 6, the sample descriptors are given as the mean and range, rather than mean and standard deviation as in the other tables. Unlike the equations of the other Services, the Air Force equations predict fat-free mass. Also, the development sample for the women's equation contained some non-Air Force individuals.

Predicted percent fat was correlated with percent fat derived from underwater weighing using the Siri equation. Table 7 shows the results of this cross-validation. Note the Air Force equation for males is only cross-validated on a sub-set of the Navy sample. This is because flexed biceps measurements were only made on a few of the Navy subjects.

Table 7.
CROSS-VALIDATION OF MILITARY EQUATIONS
ON NAVY SAMPLE

	Correlation Coefficient	Mean Difference (% Fat)	Standard Error of Measurement (% Fat)
U.S. ARMY			
Males:	0.89	3.15	3.73
Females:	0.79	-0.17	4.39
U.S. NAVY			
Males:	0.89	0.02	3.63
Females:	0.84	-0.17	3.82
U.S. MARINE CORPS			
Males:	0.87	-0.75	4.05
Females:	0.80	-2.88	4.25
U.S. AIR FORCE			
Males:*	0.74	2.67	5.17
Females:	0.78	4.18	4.45

* Cross-validation on only 52 Navy subjects.

It is apparent from Table 7 that predicted fat was rather highly correlated with hydrostatic fat in all of the equations. More importantly, the standard errors of measurement seen here with these equations are comparable to those seen with other generalized equations in common use, including those utilizing skinfolds (Durnin and Womersley, 1974; Jackson and Pollack, 1978; Jackson, Pollack, and Ward, 1980). Hodgdon and Beckett (1984a, 1984b) and Wright, Dotson, and Davis (1980) have already shown that generalized circumference and skinfold equations have similar validities when applied to the same population sample.

CONCLUSION

There are two major summary points to be made here: There is, admittedly, a need to validate the relationship between body composition and health outcomes suggested here. However, it would appear at present that the most rational basis for the setting of body composition standards is health considerations.

The military Services have used standard techniques to derive equations to estimate relative body fat from anthropometric measures: Body circumferences, height, and weight. When applied to a general military population sample, these

equations have similar validities and standard errors of measurement to other, published generalized anthropometric equations, and would appear to be reasonable, useful estimators of body composition.

REFERENCES

Allen, T.H. (1963). Measurement of human body fat: A quantitative method suited for use by aviation medical officers. Aerospace Med. 34:907.

Beckett, M.B. and J.A. Hodgdon (1987). Lifting and carrying capacities relative to physical fitness measures. Report no. 87-26. Naval Health Research Center, San Diego, CA.

Beckett, M.B., J.H. Heaney, and J.A. Hodgdon (unpublished). Skill acquisition for selected skinfold and circumference measurements. Naval Health Research Center, San Diego, CA.

Brennen, E.H. (1974). Development of a binomial involving anthropometric measurements for predicting lean mass in young women. Thesis in partial fulfillment of Master of Science requirements. Department of Biology, Incarnate Word College, San Antonio, TX.

Department of Defense Directive No. 1308.1 (29 June 1981). Subject: Physical fitness and weight control programs. ASD(MRA&L).

Department of the Air Force Regulation 35-11 (10 April 1985). The Air Force weight and fitness programs. HQ AFMPC/MPCASD.

Department of the Navy (24 July 1986). Marine Corps Order 6100.10a. Subject: Weight control and military appearance. HQMC/TDE-32.

Department of the Navy (07 Aug 1986). Office of the Chief of Naval Operations Instruction 6110.1C. Subject: Physical readiness program. NMPC-6H.

Durnin, J.V.G.A., and J. Womersley (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged 16 to 72 years. Brit. J. Nutr. 32:77-97.

Fuchs, R.J., C.F. Theis, and M.C. Lancaster (1978). A nomogram to predict lean body mass in men. Am. J. Clin. Nutr. 31:673-678.

Hodgdon, J.A. and M.B. Beckett (1984a). Prediction of percent body fat for U.S. Navy men from body circumferences and height. Report no. 84-11. Naval Health Research Center, San Diego, CA.

Hodgdon, J.A. and M.B. Beckett (1984b). Prediction of percent body fat for U.S. Navy women from body circumferences and height. Report no. 84-29. Naval Health Research Center, San Diego, CA.

Hodgdon, J.A., P.I. Fitzgerald, and J.A. Vogel (1990). Relationships between body fat and appearance ratings of U.S. Soldiers. Report no. 90-01. Naval Health Research Center, San Diego, CA.

Jackson, A.S. and M.L. Pollack (1978). Generalized equations for predicting body density of men. Brit. J. Nutr. 40:497-504.

Jackson, A.S., M.L. Pollack, and A. Ward (1980). Generalized equations for predicting body density of women. Med. Sci. Sports and Exercise. 12:175-182.

Mueller, W.H., and R.M. Malina (1987). Relative reliability of circumferences and skinfolds as measures of body fat distribution. Am. J. Phys. Anthropol. 72:437-439.

National Institutes of Health (1985). Health implications of obesity. National Institutes of Health Consensus Development Conference Statement, vol. 5 no. 9. U.S. Department of Health and Human Services, Washington, DC.

Robertson, D.W. and T.T. Trent (1985). Documentation of muscularly demanding job tasks and validation of an occupational strength test battery (STB). Report No. 86-1. Naval Personnel Research and Development Center, San Diego, CA.

Siri, W.E. (1961). Body composition from fluid spaces and density: Analysis of methods. pp 223-244 In: J. Brozek and A. Henschel (eds). Techniques for Measuring Body Composition. National Academy of Sciences, National Research Council, Washington, DC.

Vogel, J.A., J.W. Kirkpatrick, P.I. Fitzgerald, J.A. Hodgdon, and E.A. Harman (1988). Derivation of anthropometry based body fat equations for the Army's weight control program. Technical report No. T17-88. U.S. Army Research Institute of Environmental Medicine, Natick, MA.

Wright, H.F., C.O. Dotson, and P.O. Davis (1980). An investigation of assessment techniques for body composition of women Marines. U.S. Navy Med. 71:15-26.

Wright, H.F., C.O. Dotson, and P.O. Davis (1981). Simple technique for measurement of percent body fat in man. U.S. Navy Med. 72:23-27.

Wright, H.F., and J.H. Wilmore (1974). Estimation of relative body fat and lean body weight in a United States Marine Corps population. Aerospace Med. 45:301-306.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: Unclassified

1b. RESTRICTIVE MARKINGS: None

2a. SECURITY CLASSIFICATION AUTHORITY: N/A

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE: N/A

3. DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S): NHRC Report No. 90-21

5. MONITORING ORGANIZATION REPORT NUMBER(S):

6a. NAME OF PERFORMING ORGANIZATION: Naval Health Research Center

6b. OFFICE SYMBOL (If applicable): Code 10

7a. NAME OF MONITORING ORGANIZATION: Chief, Bureau of Medicine and Surgery

6c. ADDRESS (City, State, and ZIP Code): P. O. Box 85122, San Diego, CA 92186-5122

7b. ADDRESS (City, State, and ZIP Code): Department of the Navy, Washington, D.C. 20372

8a. NAME OF FUNDING / SPONSORING ORGANIZATION: Naval Medical Research & Develop. Command

8b. OFFICE SYMBOL (If applicable):

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c. ADDRESS (City, State, and ZIP Code): Naval Medical Command National Capitol Region, Bethesda, MD 20814-5044

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
63706N	M0096-PN	.002	6003

11. TITLE (Include Security Classification): (U)Body Composition in the Military Services: Standards & Methods

12. PERSONAL AUTHOR(S): J. A. Hodgdon, Ph.D.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM ______ TO ______	1990 September 28	16

16. SUPPLEMENTARY NOTATION:

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number): military service, predictive equations, anthropometric measures, body circumference

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This paper deals with two topics: The development of body composition standards in the U.S. Navy; and the methods of body composition assessment in use by the military Services today. In 1981, the Services were directed to develop body composition and fat standards consistent with the mission of the Services. Three concerns were outlined which dictated the establishment of weight control policy; 1) body composition was an integral part of physical fitness; 2) body composition is a determinant of appropriate military appearance; and 3) body composition is a determinant of general health and well-being of military personnel. Each of these three concerns was explored as a basis for setting standards for body composition in the Navy. Our investigations of relationships between body composition variables and performance of materials handling tasks suggest that percent fat is not strongly related to such performance. Estimated fat-free mass, on the other hand, is highly correlated with strength and the ability to lift objects. Investigations of relationships between rated military appearance and percent body fat by Vogel and colleagues reveals military appearance
(continued on reverse)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION:

22a. NAME OF RESPONSIBLE INDIVIDUAL: Dr. J. A. Hodgdon

22b. TELEPHONE (Include Area Code): (619) 524-4525

22c. OFFICE SYMBOL: Code 10

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

☆U.S. Government Printing Office: 1985—507-047

19. (continued)

can be determined reliably, and that percent body fat is only moderately well correlated with military appearance (r = 0.53 for men; 0.46 for women). Fatness was not found, by itself, to be a reasonable indicator of military appearance. In 1985, the National Institutes of Health determined, based on the findings of a consensus conference on body composition and health, that obesity (defined as a fat level posing significant health risk to the individual) could be defined as a body weight for height which exceeded the midpoint for the medium frame individual on the 1983 Metropolitan Life Insurance tables by 20%. A study was undertaken to determine the percent fat equivalent of this weight-based definition. Equations were developed from the Naval Health Research Center body composition data base to predict percent fat from height and weight. These equations were applied to the 120% weight values for each height. Percent fat values were found to be rather constant across heights, especially for females. Mean values for critical percent fat across height were 22.0 ±1.20 for males, and 33.5 ±0.18 for females. Standards for Navy personnel were based on these critical percent fat values. Since the Navy equations to predict fat have standard errors of about 3.5% fat, it was decided that the standard for administrative action should be at least one standard error above the critical percent fat values. Thus the Navy standards of 26% fat for males and 36% fat for females, were arrived at. It was concluded that while there is a need to validate the relationship between body composition and health outcomes expressed in this paper, the most rational basis for setting body composition standards for the military appears to be health considerations. In the measurement of body composition, all four Services have adopted the use of body circumferences, in conjunction with height and weight, to predict percent body fat. Circumference measurements are made more reliably and learned more easily than skinfold thickness measurements. Circumference measurement sites selected for prediction equations varies by gender and Service. Multiple correlations for the development of the equations range from 0.73 for the Marine Corps female equation to 0.90 for the Navy male equation. Cross-validation of the military equations on a sample of U.S. Navy personnel shows the percent fat predicted from the equations to have a mean correlation of 0.85 (range = 0.89 to 0.74) for males and a mean correlation of 0.80 (range = 0.84 to 0.78) for females with percent fat from hydrostatic weighing. Standard errors of measurement average 4.15% fat for males and 4.23% fat for females. It was concluded that the equations in use by the military Services have similar validities and standard errors of measurement to other, published generalized anthropometric equations, and would appear to be reasonable, useful estimators of body composition.